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ABSTRACT

It was hypothesized that nonverbal auditory-visual processing skills relevant to reading could be investigated through a music program structured to parallel the verbal decoding process. The current investigation consisted of three endeavors: the development of a nonverbal reading prototype (through the application of music); the development of a nonverbal auditory-visual instructional program (based upon the reading prototype); and an examination of the differences between poor and good readers in learning the instructional program (with particular attention directed toward specifying the auditory-visual processing difficulties experienced by poor readers). Twenty second grade students in a Watertown, Massachusetts public school participated in this study. Results indicated that auditory processing skills of a sequential nature may be of critical importance to reading competence, and encourage extended applications of music as a culture-free educational medium. (Author)

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THE USE OF MUSIC FOR A NONVERBAL READING PROTOTYPE: AN INVESTIGATION OF AUDITORY-VISUAL PROCESSING IN POOR AND GOOD READERS*

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Judith R. Berman, Ed.D.

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Background

The growing evidence that reading acquisition and reading competence may be critically related to nonverbal auditory and visual informational processing skills warrants careful further attention. Specifically, during the past several years a bulk of investigations have pointed out that the auditory-visual (A-V shall be used hereafter) process of "associating" or "integrating" nonverbal sounds with nonverbal symbols may constitute critical basic reading subskills. Data have indicated that early reading competence significantly correlates with ability to perform nonverbal A-V associational tasks, with dyslexic and poor readers displaying a significant deficit in nonverbal A-V processing (Birch & Belmont, 1964, 1965; Muehl & Kremenak, 1966; Beery, 1967; Gascon & Goodglass, 1970; Clark, 1970); and that performance on

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nonverbal A-V tasks at the pre-reading levels can significantly predict later reading difficulties (Geschwind, 1965; Muehl & Kremenak, 1966; Beery, 1967; Jones, 1972).

The implications of these findings may have important bearing in several areas. In the area of reading instruction, for example, it should be considered that early reading experience may be best structured to focus on acquisition of nonverbal "decoding" skills. In the development of remedial programs and strategies for "poor" readers and students who are at high risk of reading failure, the utilization of a nonverbal A-V framework may also be extremely important. Such considerations may also have important applications in the area of diagnostics, where it may be critical to specify the nature of the A-V difficulties experienced. Implicit in these data, too, is the general consideration that further understanding of the reading process and reading disorders may require more specifications of the nonverbal A-V process.

While such considerations have been frequently stressed, however, it has appeared that a plateau currently exists in these areas of applications. While we know, for example, that nonverbal A-V processing bears directly on early reading performance, we have not developed comprehensive reading programs which include A-V reading subskill components. We have not developed A-V "perceptual" strategies for remedial programs to help reading disabled

students (note Bortner's recent review in The Second Review of Special Education, 1974). We have not investigated or determined where specific difficulties occur in A-V processing for poor readers beyond the finding that "association" or "integration" is a general difficulty (Bryan, 1974); and, finally, we have not developed effective diagnostic instruments or procedures for deriving such information.

A review of what has attributed to this plateau led to the conclusion that of primary importance may be the lack of a reading-specific nonverbal A-V model. Specifically, the traditional nonverbal A-V model used may not have taken into account the complexity of the A-V tasks required in reading sufficiently enough to allow for further instructional and diagnostic applications. The traditional model, that is, has consisted of tasks requiring the matching of beeps or taps with dot or light patterns (i.e., tap, tap, pause, tap would be matched with .. .) Such tasks do not reflect the complexity of the A-V tasks in reading, but represent rather a general sound-symbol association model. It should be stressed that the A-V tasks in reading involve far more than matching the same single sound (tap or beep) with the same visual patterns (dots or lights). In reading it is necessary to perform such A-V tasks as discriminating different sounds from one another, pairing sounds with visual forms which differ from one another, while blending sounds in sequences of various com-

plexities - within an organized system of sounds and symbols. It may very well be that focusing in on these more complex reading-specific aspects of A-V processing is critical to further applications - and that the traditional model has posed serious limitations in not providing for reading-specific A-V parameters.

It may be critical, at the current time, that is, to work toward the development of an A-V "reading prototype" in which nonverbal sounds and symbols are structurally organized to simulate the verbal elements in reading; and from that starting point to proceed to investigations directed toward diagnostic and instructional applications.

With these considerations in mind, the current investigation consisted of three endeavors: (1) the development of a nonverbal A-V reading prototype; (2) the development of a nonverbal A-V instructional program, based upon the prototype; and (3) an examination of the learning profiles of good and poor readers, with particular emphasis directed toward identification of specific A-V difficulties experienced by poor readers. The following sections of this report shall review and describe these endeavors.

Development of a Nonverbal A-V "Reading Prototype"

In developing a nonverbal reading prototype, it was considered that the prototype use a sound-symbol system which could include discrimination and blending A-V tasks. As pointed out

earlier, the traditional nonverbal model used in previous investigations did not allow for these aspects of A-V processing. A review of possible solutions suggested that music could provide an effective medium for developing a reading specific nonverbal prototype. A task-analysis of the sound-symbol structures of both music and reading were, therefore, conducted, and it was found that there were many formal structural similarities between the two systems. Briefly, it was pointed out that both systems are systems in which different sounds are to be discriminated from one another; can be organized in single or blended forms, can be organized in various rhythmic units, and can be paired with a corresponding visual system. An outline of that comparison is provided in Table 1 of this report.

Based upon the one-to-one correspondence possibilities of such a comparison, a nonverbal A-V reading prototype was designed with music tasks analagously following the verbal A-V tasks required in the reading decoding process (auditory recognition, recall and reproduction; visual recognition and recall; and auditory-visual pairing.) Discrimination of phonemic sounds, for example, were structured nonverbally as discrimination of tonal sounds - and discrimination of visual grapheme symbols (alphabet letters) were structured nonverbally as discrimination of the music noteme symbols. Dimensions were provided in each case for the type of sound-symbol (single or blended), and the

TABLE 1

A STRUCTURAL COMPARISON OF MUSIC AND READING SYSTEMS

Music	Reading
1. A tonal system is a sound system in which different sounds are subsumed. Thus, it is a system in which discrimination of different sounds are required a. Each of these different sounds can be paired with a visual match as is the case in music.	1. The sound system for reading the English language is one in which different alphabetical phonemes are subsumed. a. These phonetic sounds are associated with a visual grapheme letter form.
2. The sounds can be organized as single sounds or blended sounds through the use of single tones and tonal harmony through chords. a. These chords can be of various complexities - i.e. 2,3 note chords (again, as in music).	2. Sounds in phonics are single sounds as in a,b,c, or blended sounds as in ch, sh, br. a. Blended phonemes in English are blends of various complexities - as in ch, cha, ough.
3. The tones can be grouped together into tonal units so that discrimination of different sounds in sequence is necessary for the decoding of the total unit - as in musical melody. a. Each of these sounds can be paired with a visual symbol match so that A-V pairs in sequence needs to be discriminated for the total unit to be decoded.	3. Phonemes in temporal sequence are unitized into words. To decode words, phonemes must be discriminated in sequence. a. Each phoneme is matched with a visual graphemic symbol - to read grapheme-phoneme, association must be decoded sequentially.

(continued)

Table 1--continued

Music	Reading
3. b. The sound-symbol units can be organized in various combinations of complexity with respect to single and blended tones as is the case, again, in music.	3. b. Words consist of various combinations of complexity of single and blended phonemes - i.e. cat, ch a t, as trin gent.
4. The tones can be presented rhythmically in a wide range of rhythmic and sound combinations. Again, as in music.	4. Words are rhythmic with stress and accent in a wide range of rhythmic and sound combinations - i.e. the words, always, processing.

sequence complexity of the sound-symbol unit (i.e., 2, 3, and 4 sound "strings" of various complexities). The proposed prototype is presented in Table 2 where each aspect of the A-V decoding process has been outlined verbally and structured nonverbally through the application of music.

Development of a Nonverbal A-V Instructional Program

Organizational format

Through application of the music-reading prototype, a "Tonal Reading" instructional program was designed to programmatically teach each A-V decoding skill outlined in Table 2. The Tonal Program was designed to initially teach auditory skills of sound recognition, discrimination, recall and reproduction; and then to introduce A-V tasks of pairing sounds to visual symbols; with the final tasks being the decoding or "translating" of the correct sound (musical) from the appropriate corresponding visual symbol (noteme). An outline of the instructional format is provided in Tables 3 and 4 where it is pointed out that the instructional program was organized into four general instructional "phases" (A B C D) consisting of general A-V decoding skills, and eight "sub-phases" which were organized with respect to (1) the type of sound - i.e., single vs. blended tones; and with respect to (2) the complexity of the sound unit - i.e., the number of sounds in the unit (i.e., two sound "strings" vs. three sound "strings" or sequences). Sub-phases were systematically organized

TABLE 2

NONVERBAL A-V READING PROTOTYPE WITH RESPECT TO VERBAL DECODING SKILLS

Nonverbal Reading Prototype	Verbal A-V Decoding Skills
Sound Recognition	Sound Recognition
individual sounds (tones) sound blends (i.e. chords) units of blends (i.e. musical phrases) blend units in sequence (i.e. melody)	phonemic sounds (i.e. letter sound "A") phonemic blends (i.e. sound "ch") words sentences
Sound Recall and Reproduction	Sound Recall and Reproduction
individual tonal sounds tonal blends units of chord blends and single tones sequences of chord blends and single tone units	phonemic sounds sound blends words sentences
Visual Recognition	
individual forms (i.e. circle, square, musical noteme) forms in sequence (i.e. musical notation in melody sequence)	alphabetic graphemes (i.e. letter form "A") words graphemically represented (i.e. the word "book")

(continued)

Table 6--continued

Nonverbal Sound-Symbol Behaviors	Verbal Sound-Symbol Behaviors
Pairing of Sound and Symbol	Pairing of Sound and Symbol (Reading)
individual sound-symbol (i.e. tone C with noteme notation symbol)	phonemic sound associated with grapheme (i.e. sound "A" with grapheme symbol "A")
sound blends with symbol (i.e. tonal chord with noteme notation)	phonemic blends associated with grapheme (i.e. "ch" sound with grapheme symbol "ch")
units of blends with symbolic units (i.e. musical phrases with noteme notation)	phonemic blends in word units associated with graphemic symbols
units of blends with symbols in sequence (i.e. melody paired with noteme notation)	phonemic blends in word units sequentially forming sentences paired with graphemic symbols

TABLE 3

TONAL READING PROGRAM PHASES OF INSTRUCTION

Phase	Instructional Presentation	Subject Response
A	Tones presented	Tones reproduced by pressing correct key(s) on organ keyboard*
B	Tones presented with simultaneous color-cued visual symbols presented on index cards (S told to "look and listen")	Tones reproduced by S as above
C	Color-cued visual symbols presented	Tones reproduced by S as above
D	Visual symbols presented (without color-cues)	Tones produced by S as above

*initially performed with stick-on-dots (not color-cued) on each of the original three organ keys involved in the tonal presentations for this study.

TABLE 4

TONAL READING PROGRAM SUB-PHASES OF INSTRUCTION

Phase	Phase Description	Sub-Phase	Sub-Phase Description
A	Tones presented	A1	Single tones presented individually
		A2-4	Single tones presented in sequences of two and three units in various combinations of complexity
		A5	Blended tones (two tone chords presented individually)
B	Tones presented with simultaneous colordued visual symbols	B1	Single tones presented individually with symbols
		B2-4	Single tones presented in sequences of two and three tone units in various combinations of complexity
		B5	Blended tones presented (two tone chords) with accompanying symbols
		B6-7	Blended tones and single tones presented in sequence units of two and three tone combinations with accompanying symbol presentation

(continued)

Table 4--continued

Phase	Phase Description	Sub-Phase	Sub-Phase Description
C	Color-cued visual symbols presented	C1	Musical notation of single tones presented to be produced on the keyboard
		C2-4	Notation of single tones in sequences of two and three tones in various combinations
		C5	Notation of blended tones (two tone chords) to be played individually
		C6-8	Notation of blended and single sounds to be played in sequences of two and three tone combinations in various complexities
D	Visual symbols presented without color-cues	D1	Notation of single tones to be played individually
		D2-4	Notation of single tones in sequences of two and three tones of various complexity
		D5	Notation of blended sounds (two note chords) to be played individually

so that for each phase the sub-phases were numerically consistent. For example, all "1" phases (i.e. A1, B1, C1, D1) consisted of instruction in single unblended tones. Following this instructional format, separate modules of instructional programs were designed for the teaching of each phase and sub-phase. For cross reference purposes, an A-V Correlate Table has been provided in this report (Table 5) where phases and sub-phases have been designated in terms of auditory and visual skills.

Method of instruction

A review of possible instructional procedures for teaching music as a nonverbal A-V decoding skill led to the conclusions that of particular attractiveness was the "key-to-tone" method devised by Maltzman (1964) in his studies of pitch discrimination. Specifically, he designed a match-to-sample behavioral method for teaching music through a perceptual-motor curriculum of matching sounds to symbols with the use of an organ teaching apparatus. This method seemed attractive on many levels, especially in that it enabled the teaching of music skills through a method which could easily be structured to follow the verbal decoding format.

With these considerations in mind, the instructional program for the present study was designed so that instruction would be conducted through a key-to-tone method of music instruction similar to that designed by Maltzman and a specially designed organ teaching apparatus was constructed for the experimental seg-

TABLE 5

BEHAVIORAL CORRELATES OF THE TONAL-READING-PROGRAM

Behavior Category	Program Phase
I. Auditory discrimination, recall and reproduction	A
of single sounds	A1
of single sounds in sequence	A2-4
two sound strings	A2
three sound strings	A3,A4
of blended sounds	A5
II. Visual discrimination	B,C,D
with color cues	B,C
without color cues	D
III. Pairing of auditory and visual information (with simultaneous presentation of both)	B,C
with color cues for visual	B
single sounds with single symbols	B1
single sounds in sequences with single symbols in sequences	B2-B4
two sound-symbol strings	B2
three sound-symbol strings	B3,B4
blended sounds with blended symbols	B5,B6,B7
single sound-symbol blends	B5
sound-symbol blend sequences	B6,B7

(continued)

Table 5--continued

Behavior Category	Program Phase
IV. Decoding auditory information from visual symbols	C,D
with color cues for visual	C
single symbols	C1
single symbols in sequences	C2-C4
two symbol sequences	C2
three symbol sequences	C3,C4
blend symbols	C5,C6,C7,C8
single blend symbols	C5
blend symbols in sequences of various complexities	C6,C7,C8
without color cues for visual (all symbols in black and white notation	D
single symbols	D1
single symbols in sequences	D2,D3,D4
two symbol sequences	D2
three symbol sequences	D3,D4
blended symbols	D5

ment of the present investigation (see Mostofsky, 1974 and Berman, 1975 for further descriptions of this method and apparatus).

The method of instruction consisted specifically of the following activities: (A) Initially tones were presented which S was required to match by pressing the correct keys of the organ. This was followed by (B) the presentation of the tone with a simultaneous color-cued visual symbol presented on an index card. Again, students were required to match the tone by pressing the correct keyboard key(s). The color-cued card was then (C) presented alone as the sole stimulus for the key press response, and then (D) standard black notation was substituted for the color-cue symbols.

Comparison of Poor and Good Readers

The experimental aspect of this investigation was directed toward comparing performances of poor and good readers on nonverbal A-V processing tasks. The particular tasks to be learned were organized as a Tonal Reading Program following a nonverbal reading prototype model as above outlined. The Program was taught to a group of twenty poor and good reading second grade students in a Watertown, Massachusetts public elementary school. Students participating were taught the Tonal Program in individual sessions for fifteen minutes daily over a three week period. Data collected consisted of: (1) the number of trials required for success criteria to be met for each phase and sub-phase of instruction;

(2) the number of errors committed before criteria was reached; and (3) the number of sessions that were required for the learning of each phase and sub-phase. Learning profiles for each student and group (poor vs. good) were subsequently constructed with respect to each of the three indices measured and comparisons were conducted comparing differences between groups. A description of these activities and the results of the data collected follows.

Sample description

Students were initially selected for participation in this study by their classroom teachers who were asked to refer students they considered to be "good" and "poor" readers. Selection criteria required that all students referred (1) were considered by their teachers to be free of any severe emotional or behavioral difficulties; (2) were assessed by the School Audiologist and the School Nurse to have normal hearing and vision on the basis of individually administered hearing and vision tests; (3) had not had previous music training, with the exception of singing instruction from the school music teacher who had not yet introduced the reading of musical notation; and (4) were of normal intelligence, as assessed in school wide screenings by the School Psychologist prior to the student's entrance into second grade.

After the initial selection of subjects, Reading Grade Levels of students were determined on the basis of their performance on the Gray Oral Reading Tests, Form B. On the basis of

these scores, final selection for participation was determined with participating students classified as being Good or Poor readers. Good Readers were considered to be those students reading at least their appropriate grade level; and Poor Readers were students reading at least eight months below their actual grade level. As a group, Good Readers ranged from reading at grade level to reading two years and four months above their grade level; and Poor Readers ranged from reading eight months below their grade level to one year and three months below their grade level.

Procedure

Participation in this project was structured so that students were taught the Tonal Reading Program as outlined above. Students were taught phases and sub-phases of instruction with the use of a specially designed organ teaching apparatus. Specifically, students were taught to match tones and noteme symbols by pressing corresponding keys on an organ keyboard. The conditions and criteria for learning the Tonal Program and for transition to succeeding phases were established as follows:

1. A total of six correct consecutive responses within ten trials were required at each sub-phase for transition to succeeding phases.
2. Three attempts at a correct response were allowed per presentation. Correct response was defined as producing the appropriate sound (or group of sounds) with

a correction technique involving not more than one incorrect response.

3. A candy reward was given only if the sound or group of sounds was reproduced without error (no corrections). The candy was delivered manually via a chute affixed to the side of the organ apparatus. These were in addition to any verbal reward or recognition as the investigator spontaneously made such comments as "good."

Results

The objective data collected consisted of (1) the number of trials required for criteria to be met for each phase and sub-phase of instruction; (2) the number of errors committed before criteria was met; and (3) the number of sessions required for criteria to be met. A summary of these data follows.

1. Trials required. In the constructing of group profiles, the number of trials required for learning the Tonal Program were grouped into two categories: (1) a substantial number of trials, where more than twenty-five trials were required for criteria to be reached; and (2) few trials, where from ten to twenty-five trials were required for criteria to be met. A summary of these profiles is presented in Figure 1 where a composite summary has been plotted to provide a comparison profile of poor and good readers.

As can be seen in Figure 1, the two groups distinguished themselves from one another quite remarkably. While Good Readers,

Number of Ss requiring more than 25 trials (N- 10/group)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 B7 C1 C2 C3 C4 C5 C7 C8 D1 D2 D3 D4 D5
Phases of tonal instruction
Legend
* —— = Poor Readers
o--- = Good Readers

Figure 1 Number of subjects in poor and good reading groups requiring more than 25 trials to reach criterion for each tonal phase

with the exception of a few cases, progressed from phase to phase with little difficulty, the Poor Readers had a frequent critical area of difficulty at Phase 2A. This phase represented the reproduction of single unblended sounds in two sound sequences. Tones were represented without visual components and Ss were instructed to listen and reproduce the tones in the same order, matching to sample by pressing the correct keyboard keys. Viewing this in terms of percentages, seventy-two percent of Ss having difficulty learning Phase 2A of the Tonal Program were found to be Poor Readers, as compared to twenty-seven percent of the group, who were found to be Good Readers. From another perspective, eighty percent of the total Poor Readers were found to be experiencing substantial learning difficulty at Phase 2A of the Tonal Program. This percentage compared remarkably with the finding that thirty percent of the Experimental Good Readers experienced substantial learning difficulty at Phase 2A.

To assess the significance of the proportion of difficulty experienced by Poor Readers during the A2-A5 phases, as compared to the proportion of difficulty experienced by Good Readers, a statistical analysis was conducted with the application of Fisher's Exact Test. (Fisher's Test is a nonparametric procedure for determining exact probability and compares to the parametric chi square procedure.) Results of the Fisher Test are listed below.

Phase	Significance
A2	P<.035
A3	P<.029
A4	P<.500 (not significant)
A5	P<.314 (not significant)

The proportion of difficulty experienced by Poor Readers as compared to the proportion of difficulty experienced by Good Readers was, thus, considered to be significant for Phases A2 (P<.03) and A3 (P<.02) where Poor Readers experienced a significant degree of difficulty.

2. Errors committed. Error profiles were compiled for Good and Poor Readers as separate groups in the same manner as the trials data described above. It should be pointed out that while the number of trials required were contingent upon the errors committed, the proportion between the number of trials and number of errors were not necessarily constant. Specifically, six consecutive correct trials were required within ten presentations for phase criteria to be met. These criteria made it possible, therefore, for Ss to commit up to four errors on the first four presentations and still meet criteria if the final six presentations were responded to correctly. On the other hand, it was also possible for Ss to make one error on the fifth presentation and not meet criteria within the ten presentations. The error profiles were, therefore, viewed as separate data from the trial profile data.

Following similar procedures to those used for the constructing of trial profiles, Error Profiles were constructed by

grouping the number of errors committed into two categories. Error categories were established as (1) a substantial number of errors where five or more errors were committed; and (2) a not substantial number of errors where less than five errors were committed for criteria to be met at each phase of instruction. A summary of these profiles is presented in Figure 2 where a composite summary has been plotted for Poor and Good Readers.

As can be seen in Figure 2, the two groups again distinctly distinguished themselves from another when number of errors were considered. This distinction mirrored the trials profile in Figure 1 in that a large number of Poor Readers were found to have committed a substantial number of errors before criteria was reached during phases requiring the reproduction of tonal sequences (to be matched from auditorily presented tones without visual cues). Comparisons between the two groups were most remarkable during the A3 phase where ninety percent of the Poor Readers committed a substantial number of errors, as compared to thirty percent of the Good Readers who committed a similar number of errors in the learning of this phase.

Applying the Fisher Test again to assess significance of group differences, the greatest amount of difficulty was found in phases where students were required to reproduce tonal sequences from auditorily presented tones. Fisher Test findings are presented below for A2-A5 phases where it can be seen that the pro-

Number of Ss who committed 5 or more errors (N=10/group)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 B7 C1 C2 C3 C4 C5 C7 C8 D1 D2 D3 D4 D5
Phases of tonal instruction
Legend
* —— * Poor Readers
o ---- o Good Readers

Figure 2. Number of subjects in poor and good reading groups who committed 5 or more errors to reach criteria at each tonal phase

portion of errors experienced by Poor Readers were significant for Phases A3 (P<.01) and A4 (P<.03).

Phase	Significance
A2.....	.08 (not significant)
A3.....	.01
A4.....	.03
A5.....	.325 (not significant)

3. Sessions required. Session profiles for Poor and Good Readers were constructed in the same manner described for trials and errors profiles. Subjects were grouped into two categories consisting of (1) a substantial number of sessions - where two or more sessions were required (thirty or more minutes); and (2) a not substantial number of sessions - where one or less sessions were required for criteria to be met (fifteen or less minutes). Profiles of Good and Poor Readers are presented in Figure 3 where it can be seen again that a pattern of learning difficulty similar to those found when trials and errors were calculated occurred when the number of sessions required were considered. The most remarkable difference between Poor and Good Readers was found to have occurred during the learning of Phase A2 tasks where ninety percent of the Poor Readers were found to have required two or more sessions to reach criteria as compared to twenty percent of the Good Readers who required a similar number of sessions. The Fisher Test was again applied for Phases A2-A5 to assess the significance of the proportions of sessions required by the two groups with their findings listed below.

Number of Ss requiring 2 or more sessions (N=10/group)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Phases of tonal instruction
A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 B7 C1 C2 C3 C4 C5 C7 C1 D2 D3 D4 D5
Legend
—— Poor Readers
o----o Good Readers

Figure 3. Number of subjects in poor and good reading groups who required 2 or more sessions to reach criteria at each tonal phase

Phase	Significance
A2.....	.003
A3.....	.035
A4.....	.50
A5.....	.07

Based upon these findings, differences were considered significant at Phase A2 ($P<.003$) and A3 ($P<.03$) with Poor Readers found to have required a significantly greater number of sessions to learn phase tasks.

Discussion of Results

The results of this study were important from both diagnostic and instructional perspectives. Diagnostically, the results of this study indicated that there may be a particular pattern to the A-V processing difficulties experienced by Poor Readers. It appeared that sequential auditory processing alone may be a critical element to the A-V processing difficulties experienced by Poor Readers. Specifically, it was found that when nonverbal A-V processing was task-analyzed into auditory and A-V components with various aspects of the total task considered separately, Poor Readers experienced substantial difficulty in only one aspect of the total task - an auditory processing aspect, as demonstrated by difficulties experienced when correct reproduction of tonal sequences (without visual components) was required. This was found to be consistently the case when trials, errors, and number of sessions were separately considered.

The fact that Poor Readers did not experience significant difficulty in learning actual A-V associational or integrational tasks in the present study warrants serious consideration. This finding is inconsistent with the many studies which have investigated A-V processing in Poor Readers (as described earlier in this report) and found that Poor Readers experience difficulty in the A-V "associational" or "integrational" area. In understanding why the findings of the current investigation are inconsistent with those of previous investigations, consideration should be made of the fact that the current investigation differed from previous studies in providing provisions for complex auditory processing tasks as well as complex A-V processing tasks. The general lack of such considerations has been noted by several investigators who have reviewed findings in this area. Bryan (1974), for example, stressed that:

> . . . most studies involving cross-modal integration failed to first determine whether there might not be intra-modal differences... Before claims can be made about cross-modal information processing, intra-modal processing must be eliminated as plausible rival hypothesis (p. 50).

Current findings may be explained, then, as not being inconsistent with previous findings but rather as providing more specific delineation of previous findings.

From an educational point of view, it must be considered that the instructional nature of the program used for the current investigation may have had some bearing on the overall results.

The fact that students were required to master each A-V skill and were provided modules of instruction through which to achieve mastery at each phase of instruction may have had strong bearing on the fact that Poor Readers did not experience A-V associational difficulties. Specifically, A-V pairing tasks (B, C. and D) were not presented in the Tonal Program until auditory tasks (A) were completely mastered. The mastering of these skills may account for the finding that subsequent presentations of A-V association tasks were mastered without difficulty. A-V association difficulties may not have occurred, thus, because critical skills affecting A-V difficulties were learned during the initial auditory phases of instruction. Indeed, A-V pairing difficulties in Poor Readers may be symptomatic of more basic intra-modal auditory difficulties which when overcome may eliminate the A-V inter-modal pairing difficulties frequently experienced by Poor Readers.

The experimental findings of this study offer support for further investigations in several areas. In the area of diagnostics, the findings lend support to those theories which have purported that reading disorders are associated with "perceptual" reading subskills. Support is given to the contention that A-V difficulties experienced by Poor Readers can be further delineated and specified. In particular, the findings lend support to investigations which have stressed the critical importance of auditory skills to reading (Flower, 1967; McNinch & Lawrence, 1971;

Zigmond, 1969). The auditory sequencing problem found in Poor Readers in the present study offer support to studies which have stressed the importance of sequential and memory tasks to effective learning and reading performance (Bannatyne, 1971; Senf & Freundle, 1971; Bakker, 1967, 1972; Lashley, 1951; Doehring, 1968; Kinsbourne & Warrington, 1963; Katz & Deutsch, 1963; Corkin, 1974). The diagnostic findings support further delineation of the nature of the auditory sequential processing difficulties experienced by Poor Readers with such considerations as inter-stimulus-interval, sequence complexity and sequence directionality considered. From an instructional perspective, the results of this study offer support for the relevance of perceptual skills instruction, and support the development of perceptual strategies in the area of sequential auditory processing.

Conclusions

Overall, the findings of this study offer encouragement for extended applications in the areas of (1) reading instruction; (2) music instruction; (3) special programming for Poor Readers; (4) diagnostic procedures for assessing the difficulties experienced by Poor Readers; and (5) screening procedures for identifying disabled readers. Specifically, one might speculate that through the application of a nonverbal reading prototype, reading programs may be structured to include both the training of non-verbal "reading sub-skills" and the teaching of verbal reading

skills. They also suggest that music programs could be utilized as a means to achieve additional academic goals. In the development of special programs for Poor Readers, the present findings suggest that programs be developed which stress the training of auditory sequential skills. Diagnostically, the present findings suggest that the difficulties experienced by Poor Readers may be more specifically identified through the development of assessment procedures which evaluate auditory functioning. Finally, these findings could have application in the development of screening procedures for identifying disabled readers in that eighty to ninety percent of the Poor Readers in this study were found to experience significant difficulty in the correct reproduction of two and three tone sequences. This particular task, therefore, may perhaps be utilized as a screening procedure for identifying Poor Readers. (In conclusion,) The fact that the Tonal Program is "culture free" offers opportunities for wide cross-cultural use.

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